SUCCESSFUL WHEAT GROWING IN SEMIARID DISTRICTS.

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INTRODUCTION.

There has been much discussion in recent years of the question of the future wheat supply of the world, and in some quarters fears have been expressed that by the end of the next thirty years we may experience a universal wheat famine, provided that the present rate of increase of the bread-eating population and the present yield of wheat per acre shall continue.[1] It is not the purpose to enter into this discussion here, except to say that the subject is at any rate one which deserves serious consideration, and is of interest from the standpoint of the agricultural scientist, as well as from that of the statistician. Whether such a failure in the wheat supply shall come sooner or later, there is no question as to the need of giving attention to all possible means of increasing the product of the lands that are already farmed. By this means there may be accomplished the double purpose of increasing not only the general supply of wheat, but also the profits derived by the individual farmer from a given amount of land. At present a very good opportunity of making improvements which shall be productive of immediate returns is to be found in the development of the semiarid districts.

There is no general agreement among agriculturists as to what part of the country may be properly called semiarid and what part should be considered completely arid. Ideas concerning the line that should separate the semiarid from the humid region are equally indefinite. In fact, there is possible need of a fourth term—semihumid—to designate a region lying between these last two. In this paper the term semiarid may be understood to refer, approximately, to that portion

[1] Sir William Crookes's presidential address before the British Association for the Advancement of Science, at Bristol, September 7, 1898; The World's Wheat Supply, by Sirs Lawes and Gilbert, London, 1898 (reprint of letter in London Times, December 2, 1898); Edward Atkinson, Popular Science Monthly, Vol. LIV, pp. 145–162 and 759–772, December, 1898, and April, 1899; John Hyde, North American Review, Vol. CLXVIII, pp. 191–205, February, 1899; C. D. Roper, Popular Science Monthly, Vol. LXV, pp. 766 and 777, October, 1899; The Wheat Problem, by Sir William Crookes, London, 1899.

of the Great Plains lying between the ninety-ninth and one hundred and second meridians, to portions of eastern Washington and Oregon, and to those small portions of the Rocky Mountain and basin States where crops are grown without irrigation. The conditions in these semiarid districts are at times very discouraging. They are characterized by great extremes, occasional abundant harvests and partial or entire failures following each other at intervals of two to five years. These occurrences are closely associated with corresponding periods of extremes in temperature and rainfall. Such extremes also occur often during the same season, so that the weather may in a single season be so favorable for one crop as to secure an excellent harvest, and yet be exceedingly unfavorable for some other crop. For example, in the middle States of the Plains it is seldom that large harvests of both wheat and corn are obtained in the same year. As the wheat harvests in this region are, with a good rainfall, always excellent compared with those of other districts, any improvements that would insure conditions favorable to a good average harvest in all seasons are of the greatest importance. There will soon be no more new lands to be opened to settlement that are suitable for wheat culture, consequently an increase in the average yield of such lands as these is one of the means which must be depended upon in order to increase the general supply of wheat. Moreover, it is a matter worthy of note that the wheats usually grown in semiarid districts possess a very high quality of grain. They are always hard-grained, and furnish a large amount of gluten of the best quality. The same climatic features that cause aridity—namely, extreme heat and drought—are fortunately those which also produce an excellent quality of grain when acting in conjunction with a soil rich in nitrogen.

IS A YEARLY CROP OF WHEAT POSSIBLE IN SEMIARID DISTRICTS WITHOUT IRRIGATION?

It is only in exceedingly small portions of the wheat-growing area, especially in Utah, Idaho, and Colorado, that wheat has yet been grown by irrigation. In all other portions where irrigation is at all desirable, it is the testimony of irrigation engineers, and is at least the general belief of cultivators, that only a very small percentage of the lands can be irrigated—perhaps no more than 10 per cent at most. But even where irrigation can be carried on the cost may be so great that the additional yield obtained thereby will not justify the practice, especially if a fair average crop be produced every year in semiarid districts without it. It is the belief of the writer that this is possible, at least, over very large areas.

It may be noted by any careful observer that occasionally there are farmers in these districts who seem always to have a good crop of wheat whatever the season, even when there may be failures of the crop all about them. As other farmers in the vicinity have the same

climate, and approximately the same kind of soil, such differences in results can not be due to differences in these conditions. They are simply due to certain methods of agriculture adopted by these farmers by which they are able to overcome unfavorable conditions of the weather. The Russian farmers who settled years ago in various portions of the Great Plains region have been especially successful in wheat growing in those localities. Coming originally from regions of constantly recurring droughts and cold winters, they have long ago learned how best to combat such adverse conditions. Many of these farmers, including a large number of the Mennonites, from the government of Taurida, who settled in McPherson, Harvey, Ellis, Graham, and other counties of Kansas, have always grown wheat quite extensively and with comparatively few failures. During the years 1895 and 1896, when the wheat crop was almost an entire failure in large portions of the Great Plains, these farmers continued to have good harvests. In the autumn of 1896 the writer visited a number of these farms in McPherson County, when most of the thrashing had been done and much of the wheat was being hauled to the markets. The usual average yield was 22 to 25 bushels per acre, and occasionally there were yields of 30 and 35 bushels. The grain generally overweighed, reaching often 62 pounds per bushel.

In south and east Russia fair average yields of wheat of superior quality are obtained where the climate is characterized by great extremes of heat and cold and the rainfall is considerably less than on our Great Plains near the one hundredth meridian. The larger part of the most valuable Russian macaroni wheat and much of the red-grained Russian and Ghirka spring wheats, in quality equaling our Dakota Fifes and Blue Stems, are produced east of the Volga, with an average rainfall of 15 inches or less; while the excellent hard winter wheats of the Crimea, Don territory, Kharkov, and north Caucasus endure the most rigorous winters and are grown with a rainfall and summer temperature similar to that near the one hundredth meridian, from Kansas to South Dakota.

The average yearly production of wheat in Kharkov government during the four years 1896–1899 was 11,438,850 bushels, with an average yield of 7.7 bushels per acre.[1] Almost one-fifth of this production is winter wheat, although the climate is apparently parallel with that of the Nebraska and South Dakota border. The normal rainfall at the city of Kharkov is 19.4 inches per annum, 2 inches less than at Huron, S. Dak.[2] Statistics, however, do not reveal the fact, known

[1] Calculated as accurately as possible from the reports of the central committee of statistics of the ministry of the interior of Russia for the years 1896–1899.

[2] All figures concerning rainfall are averages taken from "Die Regenverhältnisse des Russischen Reiches" (Wild), S. 12–28, Kaiserl. Akad. der Wissensch., St. Petersburg, 1881 and 1887; also "Report of the Chief of the Weather Bureau" (Harrington), 1891–92, U. S. Dept. Agr., Washington, 1893.

to the writer, that a large part of the fall-sown crop of the most excellent quality is grown east of the city of Kharkov, where the climate is much more severe, characterized especially by dry, cold winter winds. In the government of Stavropol, in north Caucasus, the average yearly production is 12,249,210 bushels, of which nearly four-fifths is winter wheat. The average yield per acre is 6.8 bushels for the years 1896–1899, including one extremely bad season. Here the temperature is milder than in Kharkov, but the rainfall is very light and particularly uncertain. In the larger part of the government, where most of the wheat is grown, no meteorological records are kept, but the rainfall probably averages under 18 inches.

On the other hand, in Kansas the average yield per acre for the part of the State lying west of the ninety-ninth meridian for the years of 1895–1899 was 6.7 bushels,[1] 1 bushel less than in Kharkov, where the climate, in both winter and summer, is much more severe.

A still better example for comparison is to be found in the wheat production of the lower Volga region of east Russia. In this region are comprised the three governments of Samara, Orenburg, and Astrakhan. The climate is characterized by the greatest extremes of heat, cold, and drought. An average of the normal yearly rainfall of six points, scattered pretty well over the entire territory, is 12.7 inches—a precipitation approaching that of regions practically arid. Yet, this is one of the principal wheat regions of Russia. The average yearly production for 1896–1899 was 44,980,050 bushels, and the average yield per acre 6.6 bushels.

For Turkestan, which in a broad sense may be considered to include Ferghana, Syr-Darya, Samarcand, and Transcaspia, no satisfactory statistics have yet been reported, but rough estimates made in the year 1892 for the report on agricultural industries of Russia, prepared for the World's Columbian Exposition, made the annual production of wheat at that time about 15,000,000 bushels, and that of all other grains about 16,000,000 bushels. The average yearly rainfall is 6 to 10 inches, or even less, and the summers are characterized by intense heat. Nevertheless, a large part of the wheat crop is grown without irrigation, though all winter wheat is irrigated. The yields per acre are not reported, but are said to be very fair, even on unwatered (bogarny) lands.

That the yield of wheat does not depend upon the absolute amount of rainfall is established by facts well known in our own country. In the Palouse region of Washington and Idaho 12 inches yearly rainfall is usually considered to be sufficient for a good crop of wheat, while in the plains States 21 inches is not supposed to be sufficient, the conditions of culture being approximately the same in the two regions.

[1] Calculated from reports of the secretary of the Kansas State board of agriculture for the years 1895–1899.

In the former region the nature of the soil makes it much better able to conserve the moisture that does fall. In that part of Oregon near The Dalles the average yield of wheat without irrigation during the last three years, according to the vice-director of the Oregon Agricultural Experiment Station, was 23 bushels per acre on summer-fallowed land. In 1900 it was 25 to 44 bushels per acre. Yet, the climatic conditions there are such as prevail in regions practically arid instead of semiarid. The rainfall at Moro, in that district, during the year November 1, 1897, to November 1, 1898, was 8.64 inches, estimating the amount for September (for which there is no record) as a mean between August and October, which, according to experience, is approximately correct.

The facts furnished by the foregoing comparisons, and many others, which lack of space precludes mentioning here, are, it seems to the writer, sufficient proof that a constant yearly crop of good average yield may be depended upon over far the larger area of the semiarid districts. The importance of such a proposition, if true, must be generally acknowledged. The question then naturally arises, how is this constant yearly crop to be secured. If we exclude such examples as those of eastern Oregon and the Palouse region, where the natural condition of the soil is unusually favorable for great conservation of moisture, it will be found that any marked increase in average yields in the semiarid districts may be secured in two ways: (1) By a proper selection of hardy varieties, and (2) by proper methods of culture.

VARIETIES BEST FOR SEMIARID DISTRICTS.

As already stated, the conditions of soil and climate of the semiarid districts are usually such as are adapted for the growth of the glutinous, hard-grained wheats. This is a matter so important that only such varieties are to be considered, as a rule, although in districts like the Palouse region the composition of the soil is such as to permit a deterioration in the gluten content of the grain. There are three general classes of wheats from which we may select varieties that are in various degrees more resistant to the adverse conditions of these districts than those now grown and therefore able to produce larger average yields. These are (1) the red spring wheats; (2) the hardy winter wheats; (3) the macaroni wheats.

RED SPRING VARIETIES.

It would hardly be supposed that any varieties of red spring wheats could be obtained better fitted for cultivation in the Dakotas than the well-known Fifes and Blue Stems now grown in those States. There are seasons, however, when even these excellent varieties are seriously damaged by drought in a large portion of this region; while there are

several varieties of the very best milling quality in extreme east Russia and western Siberia, which in such seasons would probably be better able to withstand the drought, as they are grown in the lower Volga region, already mentioned as a region of the severest extremes of climate. These varieties are both bearded and beardless, the best sorts, however, being bearded. Probably the best one of all is the variety called simply Russian,[1] a bearded sort, very hard, red-grained, and extremely resistant to drought. It produces fair crops under conditions as arid as those of the Ural and Turghai territories, just across the Ural River in Siberia. The next best sort of this class is the variety Spring Ghirka, so commonly grown as to have become the chief export variety of the Volga region. It is without beards and possesses a grain with a thin bran and a very large percentage of gluten of excellent quality. It is rather similar to the Fife wheats of this country. Judging from many series of analyses made of various wheats, it is probable that these varieties possess the highest gluten content known among bread wheats.

HARDY WINTER VARIETIES.

The establishment of winter varieties is the most difficult problem in the entire work of securing wheats adapted to semiarid conditions. The difficulties in the way are double those encountered in connection with spring wheats, since the winter sorts have to withstand both drought and cold. The effect of the cold is also all the more severe because of the accompanying drought. Nevertheless, if once such varieties are successfully established and the winter-wheat area in these districts thereby widely extended, the importance of the accomplishment will probably be admitted by all wheat growers. In addition to the well-known general truth that the same variety sown in the autumn, if able to withstand the winter, will usually give a larger yield of better grain than if sown in the spring, it is also true that winter varieties are able in particular instances to overcome the effects of spring drought better than spring-sown grain, because of their great reserve force in the amount of root growth attained the previous autumn. Besides, winter sorts are often more likely to escape certain diseases on account of their earlier maturity.

To show the value of the use of these hardy varieties of the Russian type one needs only to call to mind the Crimean wheat, known under the misleading name of Turkey, which has been grown for twenty-five years or more in Kansas, and is now also grown extensively in Nebraska, Iowa, and Oklahoma, and to a lesser extent in other parts of the country. By its hardiness it has entirely revolutionized the winter-wheat industry of the middle Plains States. Fresh importations of seed from the Crimea or other parts of the government of

[1] No. 2955 of the Section of Seed and Plant Introduction of this Department.

D. G. Passmore.

A. HOEN & CO. LITHOGRAPHIC, BALTIMORE.

DROUGHT-RESISTANT WHEATS—HARD WINTER VARIETIES.

1, TURKEY (CRIMEAN); 2, ODESSA WHITE CHAFF; 3, ODESSA RED CHAFF; 4, ROUMANIAN WHITE CHAFF; 5, KHARKOV; 6, ULTA.

Taurida have been made at different times, until now the variety is universally recognized as an indispensable component of the agriculture of these States. By means of this single variety alone the winter-wheat flour of these States has risen in reputation to be a well-recognized rival in foreign markets of the output from Minneapolis and Budapest. Its cultivation has at the same time caused a very marked extension of the winter-wheat area, which was not before possible because of the severity of the winters.

Even this variety, however, occasionally succumbs to the winters in parts of Iowa and Nebraska, and fails entirely in South Dakota, Minnesota, and Wisconsin, where winter wheat ought to be and probably can be grown. It is therefore very desirable to secure varieties still hardier than the Turkey. That it is possible to do so appears now almost certain from investigations made by the writer during the past two years in east and south Russia.

The region of Russia from which, at present, the hardiest winter wheats originate includes the following governments: Southern Kherson, Taurida (including the Crimea), Ekaterinoslav, Kharkov, Don territory, Voronezh, the southern portions of Tambov and Saratov, the northern portion of Kuban territory, and the northern and eastern portions of Stavropol. The region corresponds very fairly with that portion of our Great Plains, including Kansas, eastern Colorado, Nebraska, Iowa, South Dakota, and portions of Minnesota and North Dakota. It lies in the middle of the black soil (chernozem) belt, and therefore includes the very richest lands, and has a climate marked by great extremes of temperature and severe droughts.

One of the best of the winter varieties to be obtained from this region is the Kharkov Winter wheat from the eastern part of Kharkov government, near Starobelsk. This district possesses a climate nearly or quite as severe as that of South Dakota. Summer droughts are common, and in winter the effect of the cold is much increased by the dry, piercing winds and absence of snow. This wheat is therefore probably one of the hardiest of all known winter varieties, and ought to be able to withstand the winters of South Dakota and Minnesota. It is bearded, and has a white chaff and very hard red grain. At this point it may be noted that all the most hardy winter wheats are bearded, and usually have a white chaff, though the grain is red. The Turkey or Crimean is of this kind. It is probable that all these Russian hardy winter varieties are of one common general type, but possess different degrees of hardiness depending upon the climate of the locality in which they are grown. (Pl. LXVII.)

The variety Beloglino, grown in the extreme northern portion of Stavropol, north Caucasus, is rather similar in hardiness to the Kharkov wheat, but is probably a little more drought resistant and perhaps a little less resistant to cold. It will therefore be adapted to districts

considerably west of the one hundredth meridian of our Great Plains, perhaps as far as extreme western Nebraska and eastern Colorado. In 1900 this variety apparently possessed the hardest, most glutinous grain of all the Russian winter wheats. The varieties Ulta and Buivola, from central and eastern Stavropol, near the Kuma River, are also very resistant to drought and of excellent quality. There is much alkali in this district, and the rainfall diminishes rapidly toward the Caspian Sea. At a distance of 150 miles east of the city of Stavropol it is probably less than 15 inches per annum. Here there are also severe dry winds, and in the driest periods the air is filled with dust.

Several other Russian varieties and certain Roumanian sorts are also quite drought resistant, and possess a good, hard red grain, but are not so resistant to cold as those just mentioned, though some of them compare very well with the Turkey in this regard. Two of the best of these are the Odessa White Chaff and the Odessa Red Chaff, grown in the district near Odessa. The grain is very hard, apparently of excellent quality, and the yield good. The best variety of Roumania, which approaches very closely in quality of grain and resistance to drought to those of extreme southwest Russia, is the Roumanian White Chaff. All of these three varieties ought to give excellent results in Oklahoma, northern Texas, and a large part of Kansas.

MACARONI VARIETIES.

The greatest endurance of drought is exhibited by wheats of the durum group, commonly called macaroni wheats. In eastern Russia, Turkestan, and Algeria these wheats flourish under climatic conditions so extreme as to be perhaps properly called arid, rather than semiarid. In these regions very fair crops are produced with 10 to 12 inches or less of rainfall per year. Experiments made by this Department with these varieties have already given sufficiently favorable results to show without question that they are admirably adapted to the driest portions of our Great Plains, and will probably prove successful also in Arizona, New Mexico, Utah, and the drier portions of Oregon and Washington.

In a number of instances these varieties, when grown in the same locality with the ordinary bread wheats in the States of the Great Plains, have given, in seasons of unusual drought, a yield two to four times as great as that of the ordinary wheats. In addition to drought resistance, these varieties have also the advantage of being resistant to the attacks of leaf rust and other parasitic fungi. On the other hand, they are very liable to injury in severe winters, and must be used as spring varieties north of the thirty-fifth parallel. South of that latitude they may be sown in October or November, and become practically winter wheats. By gradual adaptation through selection they may be made later to endure the winter farther north. As winter varieties they furnish abundant fall pasturage.

FIG. 1.—FIELD OF MACARONI WHEAT, NEAR THE AZOV SEA, RUSSIA.

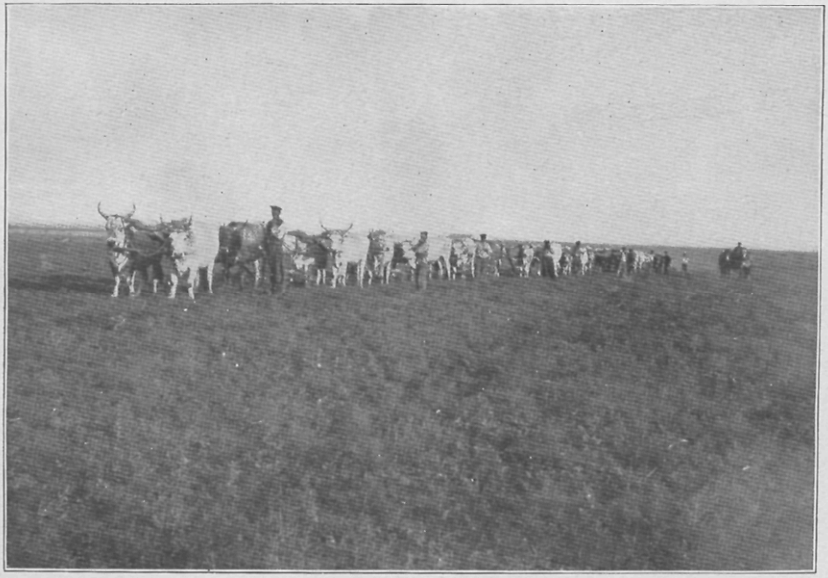


FIG. 2.—PLOWING THE "BLACK FALLOW" ON A LARGE ESTATE IN NORTHERN TAURIDA, RUSSIA.

Proctor.

A. HOEN & CO. LITHOGRAPHIC, BALTIMORE.

DROUGHT-RESISTANT WHEATS'—MACARONI VARIETIES.

1, KUBANKA; 2, NICARAGUA; 3, VELVET DON; 4, BLACK DON; 5, WILD GOOSE.

Apparently the only obstacle in the way of complete success with macaroni wheats is the present uncertainty of the market—an obstacle, however, which will no doubt very soon disappear. As these wheats are employed almost solely for making macaroni and similar pastes, a market will have to be found either for export to southern France and Italy, or by stimulating sufficient demand among our own macaroni factories to establish a home market. At present our own factories make their macaroni from the common bread wheats, using, especially, flour from the Minneapolis and Kansas mills. Already some of these factories would be glad to use the true macaroni wheats if they could readily obtain the flour. As the factories do not grind their own flour, the one thing remaining is to create a sufficient interest among the flour mills to induce them to provide the proper machinery for grinding these wheats. They are so much harder than even the hardest of our bread wheats that certain changes in milling machinery are apparently needed in order to be able to grind them.

When macaroni wheat is mixed with 20 or 25 per cent of red wheat in grinding, it also makes what is considered in eastern Russia an excellent quality of flour for bread. In fact Kubanka, the chief macaroni variety, is the most popular for making bread in that region. All the mills along the Volga grind this wheat in large quantities.

The three principal varieties of macaroni wheats imported on a large scale by the factories of France and Italy are Gharnovka, or Arnautka, from the Azov Sea region, and Kubanka and Beloturka from eastern Russia. (Pl. LXVIII, fig. 1.) These are all white chaff sorts, with yellowish white grains, appearing vitreous in fracture, and are of the highest grade among macaroni varieties. A black-bearded variety with velvet chaff and dark-colored grains, and a black chaff variety are also grown in the Azov and lower Volga regions. (Pl. LXIX.) All these varieties have been introduced by the Department of Agriculture and distributed through the State experiment stations. The variety Sarui-bugda is an excellent white-chaff sort, grown mostly in Turkestan. A number of valuable varieties of macaroni wheats are also grown in Algeria, of which Medeah, Pellissier, and El Safra are among the best known. These Algerian sorts are probably best adapted in this country to districts south of the thirty-fifth parallel. Polish wheat is also sometimes used for making macaroni and other pastes. It is grown principally in south and east Russia, Turkestan, and the Mediterranean region.

In the Palouse region and similar districts, the natural conditions being rather exceptional, there is also a special demand for wheats of the club, or square-head, group, or sorts of a similar nature, which are good yielders, ripen early, do not shatter, and though drought resistant are at the same time soft wheats. Such varieties are found in Turkestan, and several of them have been introduced by the Department.

METHODS OF CULTURE.

The selection of hardy varieties is an especially favorable means of *extending* the wheat area or the area for a certain class of wheats. To aid in making a good yearly crop within this area *constant* and *certain* it is necessary, in addition, to practice proper methods of culture. Even with an excellent variety in use, there are localities where the majority of the farmers have concluded that it is impossible to produce a paying crop each year, and that occasionally an entire failure is inevitable on account of drought or the severity of the winter. But, as already mentioned, there are often other farmers in the same localities who continue to have good harvests year after year, with the same natural conditions of climate and soil. By proper treatment of the soil these farmers have simply conserved moisture that the others have lost, and which was necessary to mature the crop. It is not simply the amount of moisture that falls, but the amount that is retained in the soil that is of chief importance. Half the average rainfall of places near the one hundredth meridian would be plenty for a crop of wheat if it could all be utilized and at the right time. In the Palouse region the soil is naturally in condition to hold much moisture. In the region of the Great Plains the farmer must aid nature by proper tillage to accomplish the same end.

TIME AND MANNER OF PLOWING.

The importance of very early plowing for wheat can not be too strongly urged. In recent years early plowing has apparently become more common than formerly, but it is not yet so universally practiced as it should be. If wheat is to follow wheat on the same land, the present crop should be removed at the earliest date possible, if for no other reason than to permit immediate plowing. For spring wheat, plowing should by all means be done the previous autumn or summer, however dry the ground may be. By alternate freezing and thawing during the winter the ground will be brought into good condition for further tillage the following spring. Let the first plowing be comparatively deep; afterwards all further cultivation should be near the surface, and should include discing or harrowing, or both, every four or five weeks (preferably after a rain) until seeding time. This process not only prevents evaporation, but keeps the land constantly and thoroughly clean of weeds.

Careful investigations will show that summer fallowing is in most instances unprofitable. In some portions of the country the practice is attended with much actual loss, which is apparently not fully realized. The object of summer fallowing is to conserve moisture and to give the soil an opportunity to accumulate a supply of certain available constituents by means of a year's rest, during which time the land is cultivated, but no crop is sown upon it. There is no doubt that much

moisture is conserved in this way, but that purpose may be largely accomplished by early plowing, and in case of spring wheat by plowing the previous autumn. Of the solid plant foods, potash, phosphates, and nitrogen are among the most important for wheat, and are usually present in great abundance in prairie regions. In the semiarid and arid districts the greater the degree of drought the less the amount of nitrogenous food there is present in proportion to mineral salts, and hence anything that will increase the supply of nitrogenous matter becomes of chief importance. It is well known that this increase is readily accomplished by the growth of leguminous crops. In the States west of the one hundredth meridian, where there is great lack of nitrogen, leguminous cropping is especially needful. In the drier portions of the Pacific coast States summer fallowing is commonly practiced every second year. It is evident that in such cases this practice can not be regarded as immediately profitable unless the value of a crop thus obtained be equal to that of the combined crops of two years without summer fallow, deducting from the latter the expense of one year's seed, harvesting, and thrashing. It is doubtful, however, if anyone ever expects such an increase of yield by this practice. Moreover, in many instances, as observed by the writer, the fallow is allowed to become covered with weeds, which exhaust the soil as much as a cultivated crop and give no returns. On the other hand, a leguminous crop will accomplish the threefold end of (1) giving an immediate profitable return from the soil; (2) of increasing the yield of the following crop of wheat; and, (3) in extreme cases, of helping to produce a more or less permanent amelioration of the soil by neutralizing the bad effects of the presence of an excessive amount of alkali.[1]

LESSONS FROM RUSSIAN METHODS.

Mention has been made of the success that has attended the practices of the Russian settlers in various localities of the Great Plains. These people have simply followed the methods they learned in their native country. In the southern and eastern wheat districts of Russia the people have contended with extremes of climate even more severe than ours for long periods of time. It should not be surprising, therefore, if they have learned to get the best results possible under adverse conditions. Even the peasants, crude as are their methods and ignorant as they would doubtless seem to us, have long been familiar with certain principles of agriculture not yet fully recognized in our own country.

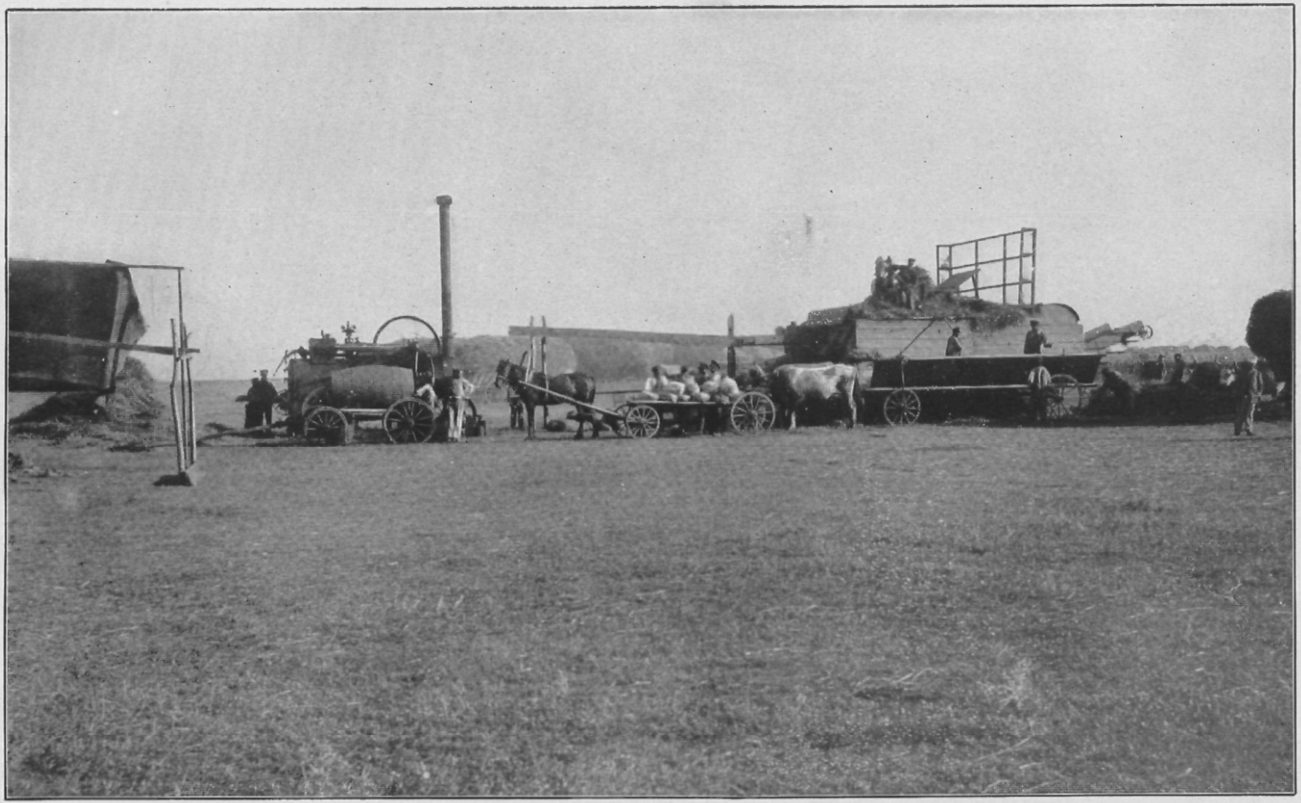
There are many systems of crop rotation followed in the semiarid districts of Russia, some of them having been practiced for a long time.

[1] See Bulletin No. 24, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture, "The basis for the improvement of American wheats," pp. 20–25.

One system consists in planting melons as the first crop (baksha) on new ground, followed by Kubanka or Gharnovka wheat (macaroni varieties), then a hard red wheat, then a softer wheat or pasture crop. The land is then allowed to rest one or two years and a similar series of crops is afterwards repeated. There are also the three, five, and seven field systems, in which by the use of several fields it is possible to grow several different crops each year without growing the same crop twice in succession on the same field, while a period of rest can be given regularly to each field also if desired. In any system it is always the aim to grow melons or macaroni wheat on new land. Summer fallowing is practiced considerably, but by no means in all cases. On the other hand, wheat is sometimes grown several years in succession on the same land, as is too often done in this country. But whatever the system of cropping and whether summer fallowing is practiced or not, early deep plowing at first and thorough tillage thereafter until seeding time are never neglected.

THE BLACK FALLOW.

Tillage among the peasants is usually with crude instruments. The plow (sokha) is a light machine of very primitive appearance, often drawn by one horse. After the first plowing, which is always as deep as the nature of their implements will allow, instead of using a harrow, the land is lightly cross plowed every month, or after every good rain, until seeding time. The wheat is sown by hand just before the last plowing. In some cases the seed is covered by a sort of harrow instead of the plow. On the lands of the more intelligent farmers and on all the large estates a much more modern machine is used in plowing. Large plows, rather similar to ours, are used in the first plowing, which is usually very deep, apparently considerably deeper than plowing is done in this country. The plows are usually ganged, two to one frame, and are drawn by three to five yoke of oxen. The driver never rides, and there is no provision for doing so. The subsequent tillage is performed by various machines, but usually by much lighter plows, five or six hung to a single frame, carried on three wheels, and drawn by two yoke of oxen. It is a common and interesting sight to see eight to twelve of these teams in a train plowing on the large estates. (Pl. LXVIII, fig. 2.) The writer has counted fifty plows of a dozen different patterns on one estate. In Pl. LXX is shown a modern method of thrashing, which is also commonly practiced on these large estates. At seeding time the harrow is used and the wheat is then drilled in. In these districts the fallowed land everywhere is so very dark in color that it is commonly called the "black fallow" (chernui par). The term seems not to be restricted, however, to fallow land, but is apparently often applied also to early plowing in preparation for fall or spring sowing. In the spring-wheat districts



THRASHING WHEAT ON THE ESTATE OF MR. GINTER AT YOSHAN-LEI, IN NORTHERN TAURIDA, RUSSIA.

Yearbook U. S Dept. of Agriculture, 1900.

it is the universal practice, with no exceptions known to the writer, to plow early in autumn, and very deep, in preparation for the following spring crop.

METHODS OF SEEDING.

The first thing of prime importance at seeding time is a fine seed bed. If the previous cultivation has been properly performed, however, this will be a condition easily attained. It should be kept in mind that after the first plowing the entire subsequent tillage of the seed bed is a life-and-death struggle, with possible drought, for the retention of moisture about the roots of the future wheat plant. If this fact were properly appreciated and heeded and the wheat sown early, there would seldom be a failure of the crop in semiarid districts in spite of the severest drought. Thorough cultivation should extend just a little way below the surface, while farther down the soil should be allowed to become packed, so that there may be the very least possible evaporation of moisture.

It is a pretty safe rule to follow the practice of sowing always at a date which is considered to be early in that locality. At the proper time the seeding should be done at once, without regard to weather conditions. Too many cases of partial or entire failures of crops have been the result of delay in seeding on account of waiting for rain or for some other cause. If a rain is expected the crop should by all means be in before it comes. The crop that is sown in good time comes up at once after the first rain, if not before, and is put far ahead of those sown just after a rain, much farther than would be caused by the difference in time alone. If a winter crop, it will have time to make a much stronger growth in preparation for the winter than the crops sown later, while in the case of spring wheats the early-sown crop, by ripening early, will be better able to escape certain diseases.

Of course, wheat seeding should always be done with the drill. The direction and depth of the drill rows are matters of the greatest importance in semiarid districts, particularly in seeding winter wheats. The drill rows of winter wheat should by all means run east and west, for the manifest reason that the rows will then be able to catch the snows if any fall, and the winds instead of driving the fine dirt out of the rows will rather drive it into the rows and around the plants.

We never fully realize what measure of success of the winter-wheat crop is dependent upon proper methods of drilling. The drill rows need especially to be made deep; but the form of the rows is also a matter of importance. The evolution of methods of seeding is about in the following order: (1) Sowing by hand; (2) the use of the seeder, simply a machine taking the place of the hand, with no force feed and not sowing the wheat in rows; (3) the ordinary drill with a force feed putting the grain in evenly in rows and deeper; (4) the press drill, which is probably the most perfect machine we have at present. We

probably do not yet have exactly the ideal drill for winter-wheat sowing in districts of extreme drought. The proper kind of machine when made will possess a combination of features found in both the press drill and what is known as the lister drill. Each hoe of such a drill should operate somewhat similarly to a corn lister, but on a smaller scale, having a broad shovel-like construction above and a short-pointed portion below and a little behind, which would be the hoe proper. The shovels should go in about as deep as in ordinary corn cultivation and the hoe proper still 1½ or 2 inches deeper, with a packer of some kind following behind. When so planted, the wheat is put so far down that the growing roots are surrounded with the abundant moisture of the packed portion of the soil, and the fine surface dirt falls in around the plant from above, filling up the row to such an extent that it will require a severe winter indeed to kill out the plant to the roots. In case of spring wheats on land plowed the previous autumn, by using the same method the moisture gathered during the winter will be so conserved about the roots that little more rainfall will be needed to mature a crop.

MAINTAINING AND IMPROVING THE QUALITY OF THE WHEAT.

The practice of the best methods of culture, with varieties most resistant to drought and cold, should still be supplemented by constant selection of the best grain each year for seeding the next crop. Having once secured a variety as nearly as possible ideal for the locality, it is then necessary to maintain the standard of the variety. But it is possible to do more than that; the variety may be so improved that it will become much hardier and more prolific than the crop produced by the original seed. The Turkey wheat, even with the crudest sort of seed selection, has shown much improvement in hardiness in recent years, and is now grown much farther north than formerly. In some instances it seems also to have improved in drought resistance. If we select the hardiest varieties at present at our command and practice the most rigid selection of seed from the hardiest plants each year, a still hardier crop will soon result, which can be successfully established in a new locality with a climate still more severe, and the same process of selection can then be repeated. It is the belief of the writer that in this way the winter-wheat area may be extended northward almost indefinitely. There is an especially good opportunity for making improvements in this way in seasons of unusually severe winters, like the year 1898–99 in Nebraska, or in seasons of unusually severe drought, if one is particular in such cases to select seed from the surviving portions of the crop in fields most exposed to the weather. Spring wheats may of course be improved in a similar way with respect to drought resistance, yield, and early maturity.